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TRANSLATION

THE RELATION BETWEEN THE SOLUBILITY OF CARBON IN FERRITE AND THE TYPE OF CARBIDES FORMED ON TEMPERING

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THE RELATION BETWEEN THE SOLUBILITY OF CARBON IN FERRITE AND THE TYPE OF CARBIDES FORMED ON TEMPERING

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It was shown earlier [1] and [2] that in a bimetallic welded specimen, one part of which consists of carbon steel and the other is alloyed with carbide-forming elements, the migration of carbon from the first part to the second on heating to 500-700° depends on the degree of carbon affinity of the alloying element and also on the carbon concentration in the alloy. The concentration gradient of dissolved carbon being formed between the unalloyed (the less alloyed) part of the compound and the alloyed (the more alloyed) part causes a directed migration of carbon. During this process, the cementite continuously dissociates in the unalloyed part and a more stable carbide forms in the alloyed part.

As a result of the carbon migration, a decarburized zone forms in the unalloyed part and we can judge the intensity of the development of this process by the depth of this zone (Fig. 1).

We studied the effect of alloying on carbon solubility in ferrite. The experiments (100 hours at 700°) on bimetallic specimens in which a metal alloyed with various elements in various amounts was fused

to unalloyed steel with 0.16% carbon, enabled us to plot the dependence of the decarburization thickness (in the unalloyed part) on the relative content of the alloyed element (M/C). It is shown in Fig. 2 that on alloying with various carbide-forming elements, certain minimum values of the M/C ratio are necessary for the decarburization process to begin.

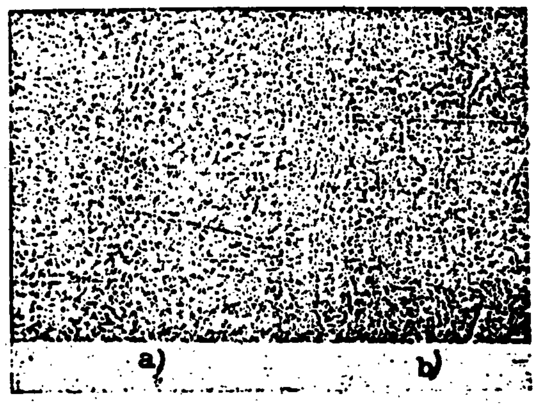

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Fig. 1. Microstructure of bimetallic steel specimen after prolonged heating at 700° (fusion boundary): a) carbon steel; b) the part of the specimen alloyed with carbide-forming elements.

Carbon depletion of the solid solution is associated with carbide-forming. To clarify this relation, a series of steels alloyed with chromium, tungsten, and vanadium with different M/C rations were exposed to x-ray examination of the carbide phase. First, hardening and holding at 700° for 100 hours was carried out.

At the same time beads of unalloyed carbon steel containing close to 0.1% carbon were applied to the alloys of this series. The built-up samples were also subject to holding at 700° for 100 hours and to metallographic investigation.

A comparison of the results of the x-ray examination and metallographic observation (Table 1) showed that the carbon migrates when

the degree of alloying with respect to the amount of carbon (the M/C ratio) is sufficient for the development of a special carbide and the carbide of a cementite type disappears.

TABLE 1

Chemical Composition in %				M/C in atom.%	Type of carbide	Carbon in surfacing in %	Carbon migration (presence of carbon-poor ferrite)
C	Cr	W	V				
0.095	0.05	-	-	0.14	Fe_3C	0.12	absent
0.095	0.54	-	-	1.3	Fe_3C	0.12	absent
0.095	2.00	-	-	4.9	Cr_7C_3	0.12	appreciable
0.11	-	0.50	-	0.03	$M_{23}C_6+Fe_3C$	0.12	absent
0.11	-	2.11	-	1.24	M_6C	0.12	exists
0.12	-	-	0.25	0.48	$VC+Fe_3C$	0.12	absent
0.12	-	-	0.65	1.27	VC	0.12	exists
0.12	-	-	1.65	3.22	VC	0.12	appreciable

These results permit the consideration that the equilibrium concentration of carbon in solution under the given conditions corresponds to various types of carbides. This concentration decreases with an increase of the binding energy of carbon in the carbide. Therefore by increasing the carbon affinity of an alloying element (or the M/C ratio) the decarburization thickness increases in a welded specimen, which characterizes a drop of carbon concentration in the solution.

The effect of alloyed elements on the process of coagulation of carbides during tempering, according to article [3], is associated mainly with the change of diffusion rate of carbon in ferrite. We

must note that an additional factor is the effect of carbide-forming elements on carbon depletion of an α-solution.

The influence of carbide-forming elements on the coagulation of the carbide phase is associated with the critical ratio $K = M/C$ in the steel. This critical ratio for a given tempering temperature determines either the presence in the crystaline structure of a mixture of carbides of a cementite type and of special type (ratio less than critical), or the presence of only special carbides (a ratio greater than critical).

In the case of the ratio $M/C < K$ three processes can occur during coagulation: 1) an increase of special carbide particles not related to the dissociation of cementite (due to smaller special carbides), 2) an increase of cementite separation due to smaller cementite particles, and 3) an increase of special carbide particles due to the cementite dissolution. Because of the small quantity of alloying element, which does not ensure production of numerous special carbide particles, the role of the first process must be small. The lower the ratio of M/C, the larger will be the role of the second process; the closer the ratio of M/C to the critical, the larger will be the role of the third process. With the increase of special carbide particles owing to cementite dissolution, a carbon depletion of the solid solution should show up near the special carbide particles in comparison with the solid solution near the cementite particle. The concentration gradient being formed should hasten the coagulation process.

When the ratio is $M/C > K$, an additional influence of the carbide-forming elements can show up if carbides with a different carbon binding energy are in the structure.

Using Fig. 2 as a guide, we can select such ratios of the degree

of alloying of the weld and base metal which guarantee an identical concentration of carbon in the solution and do not effect its migration during prolonged heating during use.

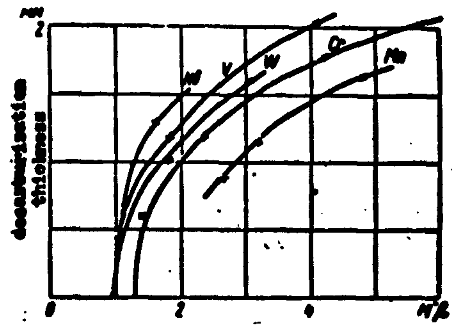

Fig. 2. The dependence of decarburization thickness in a welded specimen on the degree of alloying.

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